Advanced eye movement and pupil monitoring technology for assessing warfighter readiness in operational environments

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Has this been entered into FIMS? No

BLUF/Summary:
Advanced video-based methods can monitor eye movements and coordinated pupil changes that reflect cognitive performance, alertness and readiness. We propose to modify a current prototype of a high resolution eye movement recording system embedded in a virtual reality display to increase the temporal measurement bandwidth and on-board processing capabilities so that it can be incorporated in operational environments. The device will be validated by an experimental demonstration that it can detect dual-task interference in the timing of reflex eye movements during and auditory signal detection task.

Brief Background:

The ability to measure voluntary and automatic eye movements in operational environments provides opportunities for unobtrusive assessment of vigilance and physiological status, whether under the sea, on land, in aircraft or in space. This proposal develops applications for mall high speed digital camera sensors that can be incorporated in head-mounted goggles or helmets to monitor eye movement performance in real-time. The current state-of-the-art for clinical applications includes algorithms for eye/[pupil size tracking and assessment of their performance of voluntary and automatic eye movements. Applications under development with stereoscopic heads-up displays allow assessment of eye movements associated with tracking in three dimensions, particularly the convergent eye movements and pupil constriction when viewing approaching objects, and predictable modification of reflex eye movement timing by concurrent sound detection tasks. [1] These technologies can now be refined and embedded in undersea, surface and air operational platforms to both monitor warfighter physiological status and inform decision support interventions.
Video-oculographic systems (10 ms sampling) need to be upgraded to match the (1-2 ms sampling) speed and precision necessary for highest precision eye tracking. Since the pupil area is monitored, one can measure simultaneously (1) eye movements, (2) pupil control dynamics and (3) coordination of eye and pupil movements. We have recently demonstrated that coordinated eye convergence movements and pupillary constriction can be used for differential diagnostic applications in mild TBI patients which includes auditory processing deficits. Since pupil responses also indicate oxygenation status at high altitudes, the clinical technology shows considerable promise for applications in a number of operational environments for unobtrusively monitoring physiological status and vigilance. We expect these technologies to be useful in detecting effects of acoustic and other directed energy exposures.

Hypothesis:

What questions does the experiment intend to answer/look at?

We will upgrade the operational capabilities of the I-Portal® Portable Assessment System (I-PASTM, Neuro Kinetics Inc., Pittsburgh, PA), by increasing the sampling rate to 1 kHz, integrating FPGA hardware into the goggles, and adjusting the form factor so that it can be nested in helmets and other displays. The sampling rate upgrade and FPGA hardware for on-board processing can be completed in six months by the current producer, Neuro Kinetics, Inc., and conduct validation testing. An experiment will test the ability of this VR device to replicate our published effects of dual task performance on the timing of

[1] Balaban, CD, Furman JM. Beat-to-beat control of human optokinetic nystagmus slow phase durations. J Neurophysiol 117: 204–214, 2017. doi:10.1152/jn.00342.2016

optokinetic nystagmus timing, which requires at least 2 ms sampling. .A positive result will provide proof-of-concept for migration of technology to human-machine systems applications in operational settings.

The Experiment:

The I-Portal® Portable Assessment System (I-PASTM, Neuro Kinetics Inc., Pittsburgh, PA), a portable 3D head mounted display system (60 degrees visual angle, 1920 X 1080 pixels) with integrated video eye tracking technology, will be upgraded by increasing the sampling rate to 1 kHz, integrating FPGA hardware device, and adjusting the form factor of the video subsystem so that it can be nested in helmets and other displays. The experiment will follow the same design as Balaban and Furman (2017) performed in laboratory setting with a different method of high resolution eye movement measurement. Briefly, ten subjects will be upright while viewing a full-field random dot pattern moving at either 30 or 60 deg/sec at constant velocity to either the right or the left during stimulus blocks lasting 90 seconds. The RT task will be a disjunctive ('go-no go') task in which subjects hold a response button in either their dominant or non-dominant hand, assigned randomly, and will be presented with either a low frequency (560 Hz) or high frequency (980 Hz) tone at 80 dB SPL intensity every 1.5-4.0 seconds via insert earphones binaurally. One tone will be randomly designated as the target tone, the other the non-target tone. They will be instructed to press the button when they hear the target tone and not to respond when they heard the non-target tone. The dependent variable will be the durations of the slow phase nystagmus eye movements, which are prolonged during presentation of the auditory processing task.

S&T to Demonstrate:

Completion of this proof-of-concept project will pave the way for migration of technology to operational human-machine systems applications in settings that use heads-up virtual or augmented reality displays..

Major goals/Schedule/Cost:

The delivery and validation of two enhanced prototype iPAS systems for continuing research. The sampling rate upgrade and FPGA hardware for on-board processing will be completed in six months and validation performance testing within 2 months.

Completion of study of effects of auditory dual task performance on timing of human optokinetic nsystagmus eye movements will be completed within four months (12 months from funding date)..

One year completion; $300,000 total costs.

Performers:

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Critical elements needed:

- Personnel (PI, Lab technician)
- Subcontract from PI to Neurokinetics, Inc. for construction of upgraded device (to be executed by Purchase Order)

Funding breakdown and path?

Award as a grant to University of Pittsburgh, Carey D. Balaban as PI.